

# Comment on: Nonlocal “Realistic” Leggett Models Can be Considered Refuted by the Before-Before Experiment

Marek Żukowski<sup>1</sup>

<sup>1</sup>*Institute of Theoretical Physics and Astrophysics,  
University of Gdańsk, ul. Wita Stwosza 57, PL-08-952 Gdańsk, Poland*

(Dated: August 30, 2008)

It is shown here that Suarez [Found. Phys. **38**, 583 (2008)] wrongly presents the assumptions behind the Leggett’s inequalities, and their modified form used by Groeblacher et al. [Nature **446**, 871 (2007)] for an experimental falsification of a certain class of non-local hidden variable models.

This comment is not aimed at a detailed discussion of the arguments given by Suarez in [1]. The sole aim is to clearly state that he misrepresents the assumptions behind the experiment described in [2], and thus the whole set of issues associated with the Leggett’s inequalities [3]. Thus the starting point of the paper is incorrect. Therefore, the conclusions of the paper have no direct logical relation with the theory and the experimental results presented in [2].

Suarez writes

- “Groeblacher et al. choose an explicit nonlocal dependence of Bob’s outcomes on Alice’s ones, though, they note, that one can also choose any other example of a possible non-local dependence. Thus, the local polarization measurement outcomes **A** are predetermined by the polarization vectors **u** and an additional set of hidden variables  $\lambda$  specific to the source. The local polarization measurement outcomes **B** are predetermined by the polarization vectors **u** and **v**, the set of hidden variables  $\lambda$ , the settings **a** and **b**, and any possible non-local dependence of Bob’s outcomes on Alice’s ones. It is a crucial trait” [1].

Let us compare the above with what is actually assumed in [2].

- “Let us consider a specific source, which emits pairs of photons with well-defined polarizations **u** and **v** to laboratories of Alice and Bob, respectively. The local polarization measurement outcomes **A** and **B** are fully determined by the polarization vector, by an additional set of hidden variables  $\lambda$  specific to the source and by any set of parameters  $\eta$  outside the source. For reasons of clarity, we choose an explicit non-local dependence of the outcomes on the settings **a** and **b** of the measurement devices.”

That is, no gender asymmetry is assumed: Groeblacher et al. choose an explicit nonlocal dependence of Bob’s outcomes on Alice’s local parameters *and Alice’s outcomes on Bob’s local parameters*. This is the starting

point for the derivation of the inequalities, and therefore the experiment of Groeblacher et al. pertains to this case.

Finally one should also explain that *only* in the Appendix I of the *supplementary information* for the paper (easily accessible in [4]) one finds a construction of an *explicit toy* non-local model, which satisfies the assumptions of the form given by Suarez. But

- Models satisfying these assumptions are a proper sub-class of Leggett-type models.
- This is just a *toy* model, the sole role of which is to show that the class of non-local hidden variable models introduced by Leggett contains one that “perfectly simulates all quantum mechanical predictions for measurements in a plane of the Poincaré sphere” [4], and therefore maximally violates the CHSH inequalities. It *plays no other role* whatsoever in any other reasoning contained in the paper.
- The model can be trivially gender symmetrized.

The work is a part of QAP (Qubit Applications), 6th EU Framework Programme. It has been done at the *National Centre for Quantum Information of Gdańsk*. The co-authors of reference [2] are thanked for discussions.

- 
- [1] A. Suarez, Found. Phys. **38**, 583 (2008)
  - [2] S. Gröblacher, T. Paterek, R. Kaltenbaek, Č. Brukner, M. Żukowski, M. Aspelmeyer, and A. Zeilinger, Nature **446**, 871 (2007).
  - [3] A. J. Leggett, Found. Phys. **33**, 1469 (2003).
  - [4] S. Gröblacher, T. Paterek, R. Kaltenbaek, Č. Brukner, M. Żukowski, M. Aspelmeyer, and A. Zeilinger, e-print arxiv.org 0704.2529v2